

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

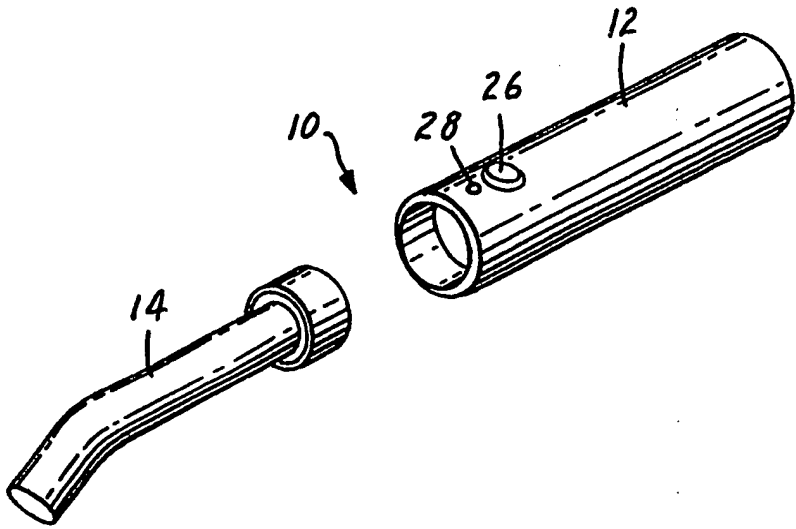
- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problems Mailbox.**

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61C 19/00, 1/00	A1	(11) International Publication Number: WO 99/22667 (43) International Publication Date: 14 May 1999 (14.05.99)
(21) International Application Number: PCT/US98/04521 (22) International Filing Date: 9 March 1998 (09.03.98) (30) Priority Data: 08/963,550 3 November 1997 (03.11.97) US (71) Applicant: MINNESOTA MINING AND MANUFACTURING COMPANY [US/US]; 3M Center, P.O. Box 33427, Saint Paul, MN 55133-3427 (US). (72) Inventors: BROYLES, Bruce, R.; P.O. Box 33427, Saint Paul, MN 55133-3427 (US). KIPKE, Cary, A.; P.O. Box 33427, Saint Paul, MN 55133-3427 (US). (74) Agents: CHRISTOFF, James, D. et al.; Minnesota Mining and Manufacturing Company, Office of Intellectual Property Counsel, P.O. Box 33427, Saint Paul, MN 55133-3427 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>With amended claims.</i>
(54) Title: HAND-HELD INTRAORAL CURING APPARATUS		
(57) Abstract An intraoral light emitting curing apparatus for curing dental material includes a housing and a source of light. The light source includes at least one laser diode that emits light within the wavelength of about 630 nm to about 1100 nm. The laser diode requires relatively little power and is compact, such that use of the apparatus in the oral cavity is facilitated. 		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

5

HAND-HELD INTRAORAL CURING APPARATUS**Background of the Invention****1. Field of the Invention**

10

This invention relates broadly to a light emitting curing apparatus for dental materials. In particular, this invention relates to a photocuring apparatus for dental materials comprising a device that provides near infrared light. More particularly, this invention relates to portable, small, hand-held, dental photocuring apparatus that has a wavelength specific laser diode for emitting near-infrared light that is utilized as the light source for photopolymerization of dental materials.

15

2. Description of the Related Art

20

Photocurable dental materials are a convenience to the dentist because the curing process can be initiated when desired. For example, a dental restorative material may be placed in a tooth cavity and manipulated as needed until the dentist is satisfied that the restorative is orientated in its proper position. A source of light held adjacent the restorative is then activated to initiate polymerization of the restorative material and to securely fix the restorative material in place in the tooth structure.

25

Light sources suggested for use in curing dental adhesives, sealants, and restorative materials often have a rigid light guide made of a bundle of optical fibers that are fused together. Such light sources are described, for example, in U.S. Patent Nos. 4,888,489 and 5,147,204, both of which are assigned to the assignee of the present invention. Unfortunately, it is somewhat difficult to use

30

such a light in the oral cavity since space in the oral cavity is somewhat limited. Additionally, the patient may experience discomfort due to heat generated by the light. As a result, the light source may not be directed toward all regions of the dental material to the photocured, resulting in an incomplete cure and possibly a failure of the dental material at a subsequent time.

5 The rigid, angled light guide that is characteristic of some known light curing apparatus is swivelable about its major, longitudinal axis in order to facilitate the positioning of the emitted light. To swivel the light guide relative to the housing of such apparatus, the light guide may be turned by grasping the light guide with one hand and gripping a handle of the housing with the opposite hand. 10 However, such a procedure maybe cumbersome in the dental operatory and difficult to quickly perform. Grasping of the light guide may also increase the likelihood of contamination of the light guide and thereby also increase the patient's risk of infection.

15 Photopolymerization of dental materials is often accomplished using a blue light (such as light having a wavelength in the range of 400 to 500 nm) that has been emitted from a broad band xenon bulb source and passed through a filter. A photoinitiator (for example, camphorquinone) absorbs the blue light and, in combination with a donor molecule, generates free radicals for photopolymerization. However, blue light emitted from a dental light curing 20 apparatus having a xenon bulb is only a fraction of the total light emitted from the bulb and thus the efficiency of the light source is limited. Moreover, during conventional intraoral photocuring procedures, considerable heat is created by the xenon bulb and a cooling mechanism such as a fan is typically provided to dissipate the heat. Both of the above-mentioned factors (i.e., the non-specificity of 25 wavelength and the heat generation by the light source) contribute to the relatively large and bulky form of dental curing lights currently commercially available. Also, such factors limit the amount of useful light energy available and tend to increase the time necessary to obtain a satisfactory cure of the dental material, 30 resulting in an increase in the practitioner's time and in the discomfort of the patient.

Moreover, fluorescent room lighting as is typically found in dental operatories provides significant photoenergy in the spectral region of 400 to 500 nm that may be absorbed by contemporary photoinitiator systems of conventional dental materials. Unless special precautions are taken, photoenergy emitted by fluorescent room lighting may be absorbed by the photoinitiator systems in a quantity sufficient to unduly limit the working time of the dental material.

Dental curing apparatus having solid state emitters have also been suggested in the past. However, to date such curing apparatus have been generally unsatisfactory for one reason or another. There exists a need in the art for a dental curing apparatus that is highly maneuverable and yet functions to cure the selected dental material within a relatively short period of time.

Summary of the Invention

The present invention is directed toward an intraoral light emitting curing apparatus that comprises a housing, a source of light coupled to the housing and a source of power connected to the light source. The light source includes at least one laser diode that emits light within the wavelength of about 630 nanometers to about 1100 nanometers.

The apparatus of the invention provides significant benefits when compared to other known light emitting apparatus for curing dental materials. The laser diode provides sufficient energy in the emitted light to satisfactorily cure dental materials such as restorative materials in a reasonable amount of time while requiring relatively little power. As a consequence, a battery may optionally be used as a source of power for the apparatus such that the apparatus can be self-contained and need not be tethered to an external source of power.

The laser diode of the apparatus also avoids the need for a fan or other cooling mechanism and as a consequence the apparatus can be relatively small and compact and light in weight. Such an apparatus is highly maneuverable, a particular advantage when used in a dental operator in instances where access to the dental material in the oral cavity is somewhat limited. Use of a solid state

mechanism avoids the need of a fan or other cooling mechanism and as a result the apparatus is relatively quiet during operation.

Brief Description of the Drawings

5

Fig. 1 is a front, top, right side perspective view in exploded form illustrating a hand-held intraoral curing apparatus according to one embodiment of the present invention;

Fig. 2 is a right side elevational view of the apparatus of Fig. 1 as it appears once assembled, and wherein a portion of a housing of the apparatus has been cut away in section to reveal inner components;

Fig. 3 is a right side elevational view of an intraoral curing apparatus according to another embodiment of the invention;

Fig. 4 is a right side elevational view of an intraoral curing apparatus according to yet another embodiment of the invention;

Fig. 5 is plan view of the apparatus illustrated in Fig. 4; and

Fig. 6 is an enlarged perspective view of a laser diode of the apparatus shown in Figs. 4 and 5.

Detailed Description of the Preferred Embodiments

20

A dental curing apparatus according to one embodiment of the invention in illustrated in Figs. 1 and 2 and is broadly designated by the numeral 10. The curing apparatus 10 includes a cylindrical housing 12 and a rigid light guide 14 that is releasably received in a socket of the housing 12. Preferably, the housing 12 has a generally cylindrical shape with a diameter sufficiently small to comfortably fit within the grip of one hand of the practitioner. An example of a suitable diameter is a diameter that falls within the range of about 0.7 cm to about 3 cm, and more preferably has a diameter that falls within the range of about 1.4 cm to about 2.5 cm.

25

The light guide 14 is swivelable about its major longitudinal axis relative to the housing 12. The light guide preferably is made of a bundle of optical fibers that have been fused together. Suitable light guides 14 include, for example, 3M 13 mm. light guide, part no. 78-8060-9552-3 from 3M Company. Other light
5 guides are also possible, such as light guides from Lumitex, Inc. or light guides made of optically clear plastics.

A semi-conductor laser diode 16 is received in an inner compartment of the housing 12 as illustrated in Fig. 2. Preferably, the laser diode 16 emits light having wavelengths in the near-infrared range of about 630 nanometers to about 1100
10 nanometers and more preferably in the range of about 700 nanometers to about 1100 nanometers. An example of a suitable laser diode is a Sharp Electronics 40 milliwatt laser diode (catalog no. LTO25MD, from ThorLabs Inc.) that emits light having a wavelength of about 780 nanometers.

The laser diode 16 is electrically connected to driver 18 that, in turn, is
15 electrically coupled to a controller 20. The driver 18 serves to modify the incoming electrical energy as needed to provide a steady or pulsed signal of a certain specified voltage to drive the laser diode 16. The controller 20 includes a microprocessor or microcontroller and provides an output for controlling the driver 18 in accordance with received input signals. As an option, the controller 20
20 prevents the electrical energy from reaching the laser diode 16 if the voltage is less than a certain predetermined value, to ensure that the light if emitted is of sufficient intensity to cure the photocurable dental material to a sufficient degree within a certain amount of time. The laser diode 16, the driver 18 and the controller 20 can be obtained as an assembly known as a laser system or projector from Lasiris Inc.

25 A source of power such as a battery 22 is electrically connected to the controller 20. Suitable batteries include, for example, alkaline batteries, size AA or AAA with an output of 1.5 volts. Optionally, the battery 22 is a nickel-cadmium rechargeable battery. Access to the battery 22 is provided through a removable side or rear battery cover. Alternatively, the source of power comprises a power
30 cord that is connected at one end to a conventional electrical outlet in the practitioner's office, and on the other end to a remote transformer that, in turn, is

electrically coupled to the controller 20. As another option, the controller, driver and transformer are contained within a second housing that is remote from but electrically coupled to the housing 12.

5 The curing apparatus 10 also includes a lens 24 that is located between the laser diode 16 and the upstream or receiving end of the light guide 14. An example of a suitable lens 24 is a polymeric collimating lens. Alternatively, a pattern head can be used, such as no. 507C concentric circle pattern head, from Lasiris Inc. Light emitted by the laser diode 16 and falling on the lens 24 is projected onto the receiving end of the light guide 14. The light is then directed along the length of
10 the light guide 14 and emitted from its outer or downstream end.

A normally off push button switch 26 is located on a outer surface of the housing 12. The switch 26 is connected by electrical leads to the controller 20 and when depressed causes the controller 20 to activate the laser diode 16. When the switch 26 is released, the controller 20 simultaneously interrupts the flow of
15 current to the laser diode 16. Alternatively, however, the controller 20 may be programmed to activate the laser diode 16 for a predetermined length of time whenever the switch 26 is depressed regardless of when the practitioner releases the switch 26.

Optionally, the controller 20 may be programmed to cause the driver 22 to
20 send a steady signal to the laser diode 16 that increases its intensity over a period of time, or to send a pulsed signal to the laser diode 16 that increases in intensity or duration (or both) over the same time period. Such operation may facilitate curing or optimize the curing in certain instances. For example, certain dental materials when cured using conventional curing apparatus may unduly in one region relative
25 to other regions, especially if light from the curing apparatus does not reach all regions in a uniform manner. By increasing the available light energy over a period of time, undue polymerization shrinkage effects caused by localized curing in the restorative material can be reduced.

An indicator 28 provides a signal that the laser diode 16 is operating and
30 emitting light. The indicator 28 as illustrated in embodiment shown in Figs. 1 and 2 comprises a solid state light source such as one or more light emitting diodes that

emit light having wavelengths in the visible range (e.g., from about 400 nanometers to about 700 nanometers). The indicator 28 provides an important advantage in alerting the practitioner that the laser diode 16 is emitting light since the light from the laser diode 16 may not fall within the range of wavelengths that are visible to the unaided eye.

The indicator 28 is located on an outer surface of the housing 12 and preferably near the front end of the housing 12 adjacent the light guide 14 so that light from the indicator 28 can be readily observed when the apparatus 10 is held in the practitioner's hand. The indicator 28 is electrically connected to the controller 20 and is activated by the controller whenever light is emitted from the laser diode 16.

As another alternative, the indicator could comprise one or more other types of signals that inform the user that the laser diode 16 is emitting light. For example, the indicator could provide an audible signal that can be heard whenever the laser diode 16 is emitting light, or that can be heard at pre-determined intervals of time (for example, a short beep that can be heard every 10 seconds). Other types of indicators include small digital or analog meters that indicate the strength of light emitted from the laser diode 16, and also vibratory mechanisms.

Furthermore, the indicator could comprise combinations of the indicators mentioned above. For example, the indicator could include indicator 28 that is present continuously whenever light is emitted from the laser diode 16 as well as an audible indicator that beeps at certain time intervals (such as 10 second intervals) during the period of time that the laser diode 16 is emitting light. Providing audible signals at predetermined time intervals advantageously enables the practitioner to determine the length of time that the photocurable dental material has been exposed to light from the laser diode 16 so that the practitioner can be assured that sufficient curing of the dental material has occurred.

Additionally, the apparatus may include a light source that provides a tracking or targeting beam of visible light that is directed along a path that is colinear to the direction of the emitted light from the laser diode 16. In such an instance, the targeting beam light source may include a solid state light source

(such as one or more red light emitting diodes or a second, lower power laser diode) that is positioned next to the laser diode 16 such that the targeting light is also directed through the focusing lens 18 and the light guide 14 simultaneously with light emitted from the laser diode 16. As a result, light from the targeting
5 light source serves to indicate the area receiving light from the laser diode 16 and also inform the practitioner that the laser diode 16 is emitting light. Light from the targeting light source according to this alternative may also serve to help illuminate the work site, a particular advantage when the work site is in a remote, posterior region of the oral cavity.

10 The embodiment of the invention that is depicted in Fig. 3 includes an intraoral curing apparatus 10a. The apparatus 10a is identical to the apparatus 10 described above except that the apparatus 10a includes a hygienic sheath 30. The remaining numbered elements are the same as like-numbered elements described above with reference to Figs. 1 and 2, and as such a detailed description of these
15 elements need not be repeated.

The sheath 30 extends over the housing 12 and the light guide 14 in surrounding relationship and is preferably made of a plastic material (such as, for example, polyethylene) having sufficient flexibility to enable the practitioner to depress the switch 26 when covered by the sheath 30. The sheath 30 preferably has
20 a sock-like configuration that matches the external configuration of the apparatus 10a for mating reception, and has a closed end adjacent the front end of the light guide 14 and an open end adjacent the rear end of the apparatus 10a for detachment of the sheath 30 from the housing 12 when desired. Alternatively, the sheath 30 could cover only the housing 12 and have an opening through which the light guide
25 14 projects.

Preferably, the plastic material of the sheath 30 is sufficiently transparent or translucent to enable the practitioner to readily view the indicator 28 and also determine the location of the switch 26 by visual inspection. In addition, the plastic material does not absorb an undue amount of the light emitted from the light
30 guide 14 during passage of the light through the sheath 30. Preferably, the plastic material is relatively inexpensive and may be disposed of after use with a single

patient, so that the likelihood of transferring communicable diseases and the like from one patient to another is substantially reduced. As an alternative, however, the sheath 30 may be made of a rigid or flexible material that can be sterilized for re-use (by, for example, an autoclaving procedure).

5 A dental curing apparatus 10b according to another embodiment of the invention is depicted in Figs. 4 and 5. The apparatus 10b includes a housing 12b that comprises a container 40b, a sub-housing 42b and a neck portion 44b interconnecting the container 40b and the sub-housing 42b. Although not shown, the container 40b includes a compartment that preferably houses a driver, a
10 controller and a battery that are similar to the driver 18, the controller 20 and the battery 22 described above.

 The container 40b as well as the neck portion 44b are elongated and extend along a central reference axis that is designated 46b in Fig. 4. As illustrated, the neck portion 44b is cylindrical and has an outer diameter that is substantially
15 smaller than the average diameter of the container 40b. More particularly, the neck portion 44b has a cross-sectional area in reference planes perpendicular to the central reference axis 46b that is less than the cross-sectional area of the container 40b as well as the sub-housing 42b.

 The sub-housing 42b has an overall generally cylindrical configuration with
20 a central axis that is designated by the numeral 48b in Fig. 4. As shown, the axis 48b extends at an angle relative to the axis 46b. The angle between the axes 46b, 48b is preferably in the range of about 0 degrees to about 90 degrees, and more preferably is in a range of about 40 degrees to about 75 degrees. Such an angle facilitates directing emitted light to various selected locations in the oral cavity.
25 Optionally, a pivotal connection is provided to couple the sub-housing 42b to the neck portion 44b and enable selective adjustment of the angle between the axes 46b and 48b.

 The apparatus 10b includes a semi-conductor laser diode 16b that is shown alone in Fig. 6. The laser diode 16b is received in a chamber of the sub-housing
30 42b and has a central axis that is aligned with the reference axis 48b. A front end

of the laser diode 16b has an optically clear window 50b that is optionally also a focusing lens.

5 The sub-housing 42b also has an optically clear window 52b that is optionally a focusing lens. The window 50b of the laser diode 16b is aligned with the window 52b. An example of a suitable laser diode is the above-mentioned 40 milliwatt laser diode from Sharp Electronics.

Electrical leads extend along an inner channel of the neck portion 44b and electrically interconnect the laser diode 16b and the driver within the container 40b. Alternatively, the laser diode 16, the driver and the controller could be
10 contained within the sub-housing 42b. Optionally, releasable coupling structure is provided to detach the neck portion 44b from the container 40b when desired so that the neck portion 44b along with the sub-housing 42b can be sterilized, for example, by an autoclaving procedure without subjecting the container 40b to the same procedure. A suitable coupling structure is a socket in the container 40b that
15 slidably and securely receives the rear portion of the neck portion 44b. Although not shown in detail, a releasable electrical connector is provided so that the electrical leads within the neck portion 44b are electrically connected to electrical leads in the container 40b whenever the neck portion 44b is connected to the container 40b.

20 Preferably, the sub-housing 42b is swivelable relative to the container 40b in reference planes perpendicular to the axis 46b. As one example, the neck portion 44b may have a cylindrical rear end portion to permit rotatable movement in the front socket of the container 40b. The neck portion 44b is moveable in an arc about the axis 46b relative to the socket in order to enable the sub-housing 42b
25 to pivot relative to the container 40b. In that instance, the electrical connector may comprise any suitable releasable, rotatable electrical connector, such as a series of spaced apart electrical contacts on the rear end portion of the neck portion 44b that engage respective, spaced apart contact rings which extend around the periphery of the socket.

30 As an option, the neck portion 44b is flexible and can be moved to any one of a number of different configurations to facilitate directing the light emitted from

the laser diode 16b in the oral cavity. In instances where the neck portion 44b is flexible, the neck portion 44b preferably retains its shape and self-supports itself as well as the sub-housing 42b.

5 Preferably, the apparatus 10b includes an indicator similar to the indicator 28 described above. The indicator may be mounted on the container 40b, on the neck portion 44b or on the rear end of the sub-housing 42b. As other options, the indicator may also comprise an audible signal or a targeting beam of light as also mentioned above.

10 Those skilled in the art will recognize that a number of other variations and additions are possible to the embodiments described above without departing from the spirit of the invention. For example, the apparatus 10b may be provided with a hygienic sheath similar to the sheath 30 mentioned above. As another example, the housings 12, 12a may be replaced by a housing having a bulged battery compartment located beneath the central axis of the apparatus or a housing having
15 a pistol-grip configuration. The housing could also have a knurled surface or one or more flat surface portions to facilitate the user's grip. A number of other modifications are also possible. As such, the invention should not be deemed limited to the specific embodiments described in detail above, but only by a fair scope of the claims that follow along with their equivalents.

20

Experimental Examples

Example 1

In this example, the photoinitiator was Dimethyl{4[1,5,5,-tris(4-
25 dimethylaminophenyl)-2,4-pentadienylidene]-2,5-cylcohexadien-1-ylidene}
ammonium perchlorate (from Aldrich). A resin composition containing 50% by weight each of Bis-GMA (diglycidylmethacrylate of Bisphenol A) and TEGDMA (triethyleneglycol dimethacrylate) was prepared. A mixture was prepared containing 2.5 g of the resin composition, 10.0 g of silane-treated filler, a solution
30 containing the photoinitiator (0.02g in ca. 0.2g acetone), a solution containing tetraheptylammonium triphenylbutylborate (0.3g in ca. 0.6g acetone), and a

solution containing diphenyliodonium SbF_6^- (0.2g in ca. 0.4g dichloromethane).

The mixture was thoroughly handmixed using a metal spatula to produce a blue mixture.

- 5 A small portion (about 1g) of the mixture was placed on a plastic surface and exposed to light from a laser diode assembly (Lasiris brand 50 milliwatt laser module, catalog no. SNF-507C-780-50) at a distance of about 3 cm. The composition rapidly photobleached within 10 seconds from the original blue color to colorless, and polymerized to a hard solid. The original control mixture remained blue and unpolymerized.

10 **Example 2**

- A mixture was prepared according to Example 1 except that the photoinitiator was $\text{IR140}^+\text{ClO}_4^-$ (from Kodak). A small portion (about 1g) of the mixture was placed on a plastic surface and exposed to light from the laser diode identified above at a distance of about 3 cm. The composition rapidly photobleached within 10 seconds from the original blue color to pink, and polymerized to a hard solid. The original control mixture remained blue and unpolymerized.

Example 3

- A mixture was prepared according to Example 1 except that the photoinitiator was $\text{IR132}^+\text{ClO}_4^-$ (from Kodak) and the resulting mixture had a pale blue color. A small portion of the mixture (ca. 1g) was placed on a plastic surface and exposed to light from the same laser diode at a distance of about 3 cm. The composition rapidly photobleached within 10 seconds from the original pale blue color to a pale blue-yellow color, and polymerized to a hard solid. The original control mixture remained pale blue and unpolymerized.

25 **Example 4**

- A mixture was prepared according to Example 1 except that the photoinitiator was $\text{IR99}^+\text{SbF}_6^-$ (from Glendale Protective Technologies) and the resulting mixture had a pale green color. A small portion of the mixture (ca. 1 g) was placed on a plastic surface and exposed to light from the same laser diode at a distance of about 3 cm. The composition rapidly photobleached within 10 seconds from the original pale
- 30

green color to a yellow color. The composition had also polymerized to a hard solid. The original control mixture remained pale green and unpolymerized.

Claims:

1. An intraoral light emitting curing apparatus comprising:
a housing, a source of light coupled to said housing and a source of
5 power connected to said source of light, said source of light including at least one
laser diode that emits light having a wavelength within the range of about 630
nanometers to about 1100 nanometers.
2. An intraoral light emitting curing apparatus according to claim 1,
10 wherein said laser diode emits light having a wavelength within the range of about
700 nanometers to about 1100 nanometers.
3. An intraoral light emitting curing apparatus according to claim 1,
and including an indicator to indicate when said laser diode is emitting light.
15
4. An intraoral light emitting curing apparatus according to claim 3,
wherein said indicator provides an audible signal when said laser diode is
operating.
- 20 5. An intraoral light emitting curing apparatus according to claim 3,
wherein said apparatus includes a visible signal distinct from light emitted by said
laser diode to indicate that said laser diode is emitting light.
6. An intraoral light emitting curing apparatus according to claim 5,
25 wherein said visible signal comprises a light beam that is essentially colinear with
light emitted by said laser diode.
7. An intraoral light emitting curing apparatus according to claim 1,
wherein said housing includes a compartment for receiving a battery.

30

8. An intraoral light emitting curing apparatus according to claim 1,
wherein said housing includes a container for receiving a battery, a sub-housing
containing said at least one laser diode and a neck portion interconnecting said sub-
housing and said container, wherein said housing has a central axis, and wherein
5 said neck portion has a cross-sectional area in reference planes perpendicular to
said central axis that is less than the cross-sectional area of said container and of
said sub-housing.

9. An intraoral light emitting curing apparatus according to claim 8,
10 wherein said neck portion is rigid.

10. An intraoral light emitting curing apparatus according to claim 8,
wherein said neck portion is flexible.

15 11. An intraoral light emitting curing apparatus according to claim 9,
wherein said neck portion may be changed to any one of a number of different,
self-supporting configurations.

12. A method of curing dental material that comprises the step of
20 directing light from a laser diode having a wavelength in the range of about 630
nanometers to about 1100 nanometers toward a photocurable dental material for a
time sufficient to at least partially cure the dental material.

13. The method of claims 11 and additionally including the step of providing an indicator to indicate when the laser diode is emitting light.

5 14. The method of claim 13 wherein the indicator provides an audible signal.

15. The method of claim 13 wherein the indicator provides a visible signal.

10 16. The method of claim 12 including the step of providing a housing that contains the laser diode as well as a battery electrically connected to the laser diode.

15

20

25

30

AMENDED CLAIMS

[received by the International Bureau on 08 September 1998 (08.09.98);
original claim 13 amended ; remaining claims unchanged (1 page)]

13. The method of claim 12 and additionally including the step of providing an indicator to indicate when the laser diode is emitting light.

5 14. The method of claim 13 wherein the indicator provides an audible signal.

15. The method of claim 13 wherein the indicator provides a visible signal.

10 16. The method of claim 12 including the step of providing a housing that contains the laser diode as well as a battery electrically connected to the laser diode.

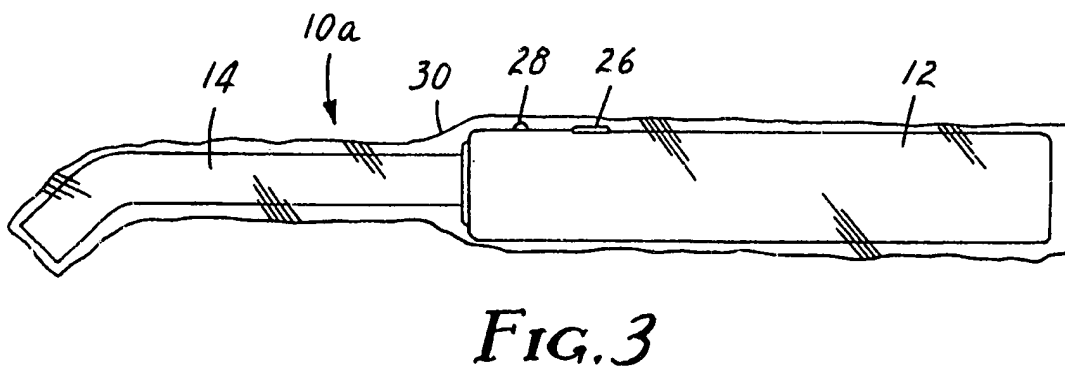
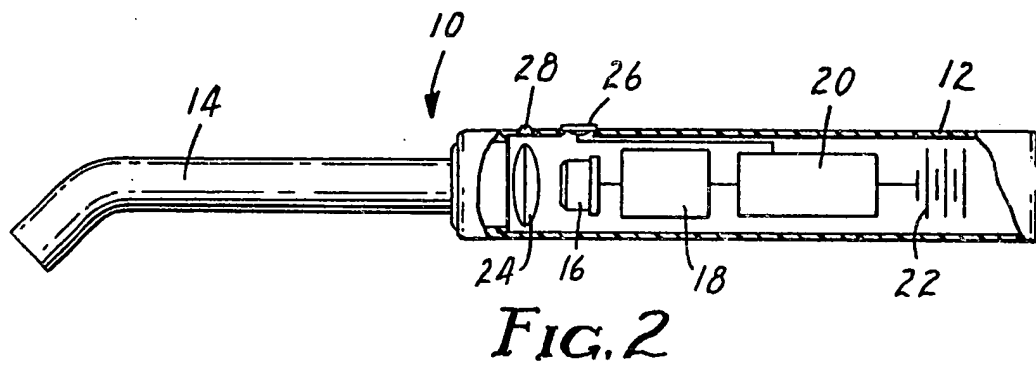
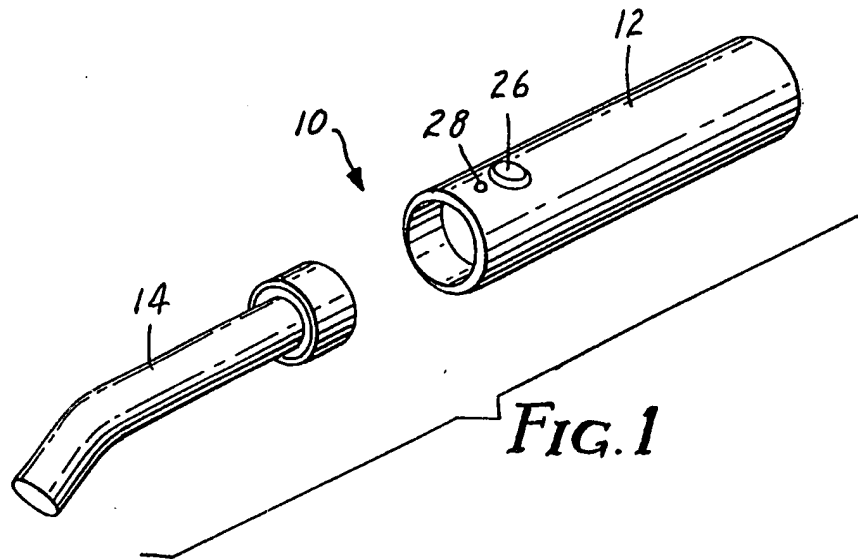
15

20

25

30

1/2



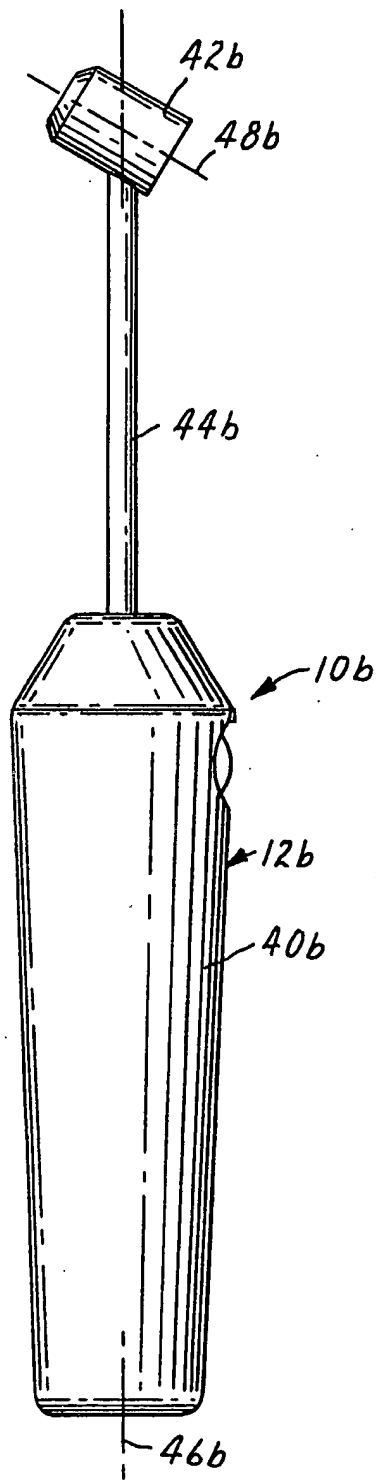


FIG. 4

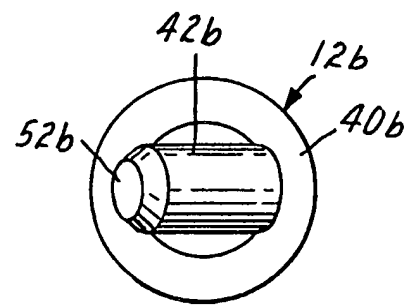


FIG. 5

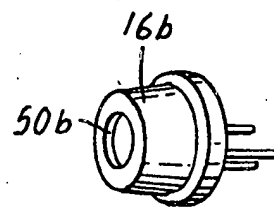


FIG. 6

INTERNATIONAL SEARCH REPORT

In .tional Application No
PCT/US 98/04521

A. CLASSIFICATION OF SUBJECT MATTER IPC 6 A61C19/00 A61C1/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 6 A61C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 678 282 A (MINNESOTA MINING & MFG) 25 October 1995 see column 5, line 45 - column 6, line 9 see column 7, line 50 - column 8, line 17 see figures 1,2	1-3,7. 12,13. 15,16
X	EP 0 619 100 A (IBM) 12 October 1994 see column 14, line 10-25 see column 18, line 49-53 see figures 9,10	1,2,12
A	EP 0 780 104 A (HERAEUS KULZER GMBH) 25 June 1997 see column 3, line 28-50 see figure 1	1-16
--- -/--		
☒ Further documents are listed in the continuation of box C.		
☒ Patent family members are listed in annex.		
Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search 2 July 1998		Date of mailing of the international search report 09/07/1998
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040. Tx. 31 651 epo nl. Fax: (+31-70) 340-3016		Authorized officer Chabus, H

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 98/04521

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 755 662 A (THERA GES FUER PATENTE) 29 January 1997 see column 3, line 39-52 see figures 1,2 -----	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/04521

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0678282 A	25-10-1995	US 5487662 A JP 7255751 A	30-01-1996 09-10-1995
EP 0619100 A	12-10-1994	CA 2102884 A JP 2723119 B JP 6254104 A US 5435724 A	05-09-1994 09-03-1998 13-09-1994 25-07-1995
EP 0780104 A	25-06-1997	DE 19619155 A AU 7418696 A CA 2190226 A JP 9183134 A AU 7418596 A CA 2190225 A DE 19619154 A EP 0780103 A JP 9187825 A	26-06-1997 26-06-1997 23-06-1997 15-07-1997 26-06-1997 23-06-1997 26-06-1997 25-06-1997 22-07-1997
EP 0755662 A	29-01-1997	DE 29511927 U JP 9028719 A	09-01-1997 04-02-1997